

APPLICATION  
FOR  
UNITED STATES LETTERS PATENT

TITLE: OPTICAL COMMUNICATIONS MODULE  
APPLICANT: TAKESHI FUJIMOTO, YOSHIKI KUHARA, HIROMI  
NAKANISHI AND KEIICHI FUKUDA

CERTIFICATE OF MAILING BY EXPRESS MAIL

Express Mail Label No. EF045062075US

July 28, 2003  
Date of Deposit

## OPTICAL COMMUNICATIONS MODULE

### BACKGROUND OF THE INVENTION

#### Field of the Invention

5        This invention relates to an optical communications module equipped with at least one optical transmitter section, one optical receiver section, or one optical transceiver section.

#### Description of the Background Art

10        An optical communications module is usually equipped with an optical transmitter section, an optical receiver section, or an optical transceiver section. The optical transmitter section includes a laser diode and an integrated circuit for operating the laser diode (a driver IC), while the optical receiver section incorporates an optical receiver device and an integrated  
15        circuit for amplifying electric signals (an amplifier IC).

      Such optical transmitter or receiver section is usually mounted on a dielectric substrate, which is entirely covered by a chassis (Refer to Japanese Patent Application Publication No.11-345987 for an example).

20        As the optical communication technology advances, there is a growing necessity to develop a smaller and less expensive optical communications module that is suited to mass production.

      When the optical communications module is downsized, the optical power efficiency of the optical communications module tends to be degraded

since the substrate and component parts are arranged more closely within the chassis, causing the temperature inside the chassis to increase by heat generated by the laser diode, the driver IC, and the amplifier IC. In addition, the receiving sensitivity of the optical receiver device and the amplifier IC  
5 also is adversely affected.

Due to such heat-associated problems, the downsizing of optical communications modules requires improvements in their heatsink efficiency.

10

## SUMMARY OF THE INVENTION

An object of the present invention is to provide a downsized and inexpensive optical communications module without the aforementioned heat-associated problems.

An optical communications module according to this invention  
15 comprises one or more dielectric substrates on which an optical transmitter section, an optical receiver section, or an optical transceiver section is provided, and a chassis encasing all of the dielectric substrates (the chassis refers to the outermost member of framework of the optical communications module), wherein at least one dielectric substrate has a metal part formed on  
20 one side thereof, the metal part constituting at least the whole or a part of an outermost surface of the chassis.

This structure allows heat to escape from the dielectric substrate to the outside of the optical communications module through the metal part, which

is formed on one side of the substrate and which constitutes the whole or part of the chassis. Thus, since the dielectric substrate provides outstanding heatsink efficiency, curbing a temperature increase within the chassis, excellent performance of the optical communications module can be  
5 achieved.

As used herein, "a metal part formed on one side of the dielectric substrate" refers to a part where a dielectric substrate and a metal plate are fixed together tightly so as to facilitate heat conduction. Such tight fixing can be attained for example by adhesive bonding, locking nuts and bolts,  
10 riveting, caulking, metal vapor deposition, plating, coating, laminating or sputtering.

The materials of the dielectric substrate include a resin such as polyimide, epoxy or polytetrafluoro-ethylene, and ceramics such as alumina. The metal plate can be produced for example from aluminum, copper, iron,  
15 gold, or silver.

A metal base substrate (a dielectric substrate laminated with a metal plate) may be employed as the dielectric substrate with the metal part formed on one side thereof. As the metal base substrate is obtained in the market, the optical communications module can be easily manufactured.

20 Thermally connecting a plurality of dielectric substrates to one another through the metal part of the chassis enables heat exchange through the metal part, which results in improvement of heatsink efficiency. "The metal part of the chassis" herein described refers to a metal part which is formed

on one side of the dielectric substrate and which is a metal part of the chassis, regardless of constituting the whole or part of the outermost face of the chassis or other part of the chassis.

If a plurality of dielectric substrates are employed and thermally  
5 separated from one another, it is possible to prevent the occurrence of heat interference between the dielectric substrates.

In terms of heat release, it is more preferable that the chassis has one or more vents.

If a multilayer wiring substrate is employed as the dielectric substrate,  
10 it is possible to expose its grounding layer to the inside of the chassis. It is preferable that a metal plate be attached to the exposed surface of the grounding layer such that the metal plate is thermally in contact with the metal part of the chassis. This results in enhanced heatsink efficiency.

The grounding layer exposed to the inside of the chassis may have a  
15 heatsink installed thereon.

When it is necessary to lead out terminals of the optical transmitter section, optical receiver section, or optical transceiver section, or if component parts need to be controlled from outside of the module, the metal part formed on one side of the dielectric substrate can be partially removed  
20 to form an opening through which the terminals and component parts are exposed to outside.

According to this invention as described heretofore, since a dielectric substrate equipped with heat-generating components is designed to have a

metal part formed on one side thereof, constituting the whole or a part of the chassis, the length of heat conduction can be minimized so that heat is efficiently released through the metal part to the outside of the optical communications module. Thus, it is possible to achieve excellent performance of the optical communications module by curbing a temperature increase that may occur within the chassis.

### BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 (a) is an exploded view of an optical communications module according to the present invention, while Figures 1 (b) is a perspective view of the optical communications module when assembled. Figure 1 (c) illustrates an example having vents on a side face of the chassis.

Figure 2 shows a sectional side view of the optical communications module of the present invention.

Figures 3 (a) and Figures 3 (b) are exploded views of a section indicated by A in Figures 2.

Figures 4 (a) and Figures 4 (b) illustrate a structure of the optical communications module whose chassis consists of resin plates except a part formed from a metal plate. Figure 4 (a) is a sectional side view of the optical communications module, while Figures 4 (b) shows its perspective view.

Figures 5 (a) and Figures 5 (b) show a structure of the optical communications module in which a plurality of metal plates are integrated into a single piece by integral molding. Figure 5 (a) is a perspective view of

the optical communications module, while Figures 5 (b) is its front view.

## DETAILED DESCRIPTION OF THE INVENTION

Hereinafter, embodiments of the present invention are described in  
5 detail with reference to the accompanying drawings. In the drawings, the  
same components are denoted by the same reference numerals, and  
redundant descriptions thereof are omitted. The proportions adopted in the  
drawings and in the descriptions are not necessarily equal to each other.

Figure 1 (a) is an exploded view of an optical communications module 1  
10 according to the present invention. Figure 1 (b) is a perspective view of the  
assembled optical communications module 1.

The optical communications module 1 is structured such that a chassis  
4, which consists of metal plates 4a, 4b, 4c, 4d, and 4e, encases therein a pair  
of dielectric substrates 2a and 2b which are arranged to face each other  
15 vertically and another pair of dielectric substrates 2c and 2d which face  
horizontally each other. The dielectric substrates 2a, 2b, 2c and 2d provide  
the photoelectric transfer function of transmitter and receiver signals, the  
electrical signal processing capability, optical signal processing capability,  
and electric/optical interface capability in connection with an external  
20 circuit (not shown in Fig. 1 (a)) outside the optical communications module 1.  
The dielectric substrates 2a, 2b, 2c and 2d can be either single-layer wiring  
substrates, or multiple-layer wiring substrates having a plurality of wiring  
layers laminated therein (Note that multiple-layer wiring substrates are

illustrated in Fig. 1 (a)).

A module 5, which is a component for conversion of electric and optical signals, is positioned between the dielectric substrates 2a and 2b.

On the rear side of the individual dielectric substrates 2a, 2b, 2c and 2d, there are metal plates 4a, 4b, 4c and 4d formed respectively and attached firmly. In other words, the dielectric substrates 2a, 2b, 2c and 2d are substrates having metal plates 4a, 4b, 4c and 4d respectively formed on the rear side thereof, and the metal plates 4a, 4b, 4c and 4d in combination with a metal plate 4e functioning as a bottom plate constitute the chassis 4 of the optical communications module 1. These dielectric substrates consisting of resin substrates with metal plates on the rear side thereof are exemplified by metal base substrates (Refer to Japanese Patent Application Publications Nos. 6-350214 and 7-297518 for example).

The metal plates 4a, 4b, 4c, 4d, and 4e are first assembled and then fixed to one another through such methods as welding, soldering, pressuring, caulking, wrapping and binding a metal band around the plates, and adhesive bonding. Fixing the metal plates 4a, 4b, 4c, 4d and 4e together facilitates heat conductions therebetween. Another example of close contact between the metal plates is illustrated in Figs. 5 and herein later.

Figure 1 (c) is a perspective view of the optical communications module 1 of the present invention, wherein vents 44 are provided in the metal plates 4c and 4d, without providing the dielectric substrates 2c and 2d on their inner surfaces. The vents 44 allow air to circulate in and out of the chassis 4,



further improving the heatsink efficiency of the optical communications module 1.

Figure 2 is a sectional side view of the optical communications module. A module 5, which is placed between the dielectric substrates 2a and 2b, is  
5 connected with an optical fiber 6 for optical connection with a network, on the front side where there is no connecting member between the dielectric substrates 2a and 2b, that is, at the front side (the side face viewed from X-direction in Fig.2) of the optical communications module.

The module 5 has a lead frame equipped with electronic circuit parts  
10 such as an integrated circuit, a resistor and a capacitor; a light emitting device exemplified by a laser diode; an optical receiver device represented by a photodiode; an Si platform; and optical circuit parts such as an optical waveguide. The module 5 is formed with a resin by transfer molding such that terminals 5a and 5b of the lead frame protrude from the upper and  
15 bottom surfaces thereof outwardly (in  $\pm$  directions indicated by Y in Fig. 2), respectively. The terminals 5a and 5b are soldered to electrodes of the dielectric substrates 2a and 2b, respectively.

Also, the top and bottom surface areas 51 and 52 of the module 5 are in contact with the metal plate 4a and the dielectric substrate 2b, respectively,  
20 so that heat generated inside the module 5 can dissipate efficiently.

The dielectric substrate 2a is equipped with various electronic parts, including adjustment electronic parts 7 such as a trimmer capacitor and a trimmer resistor, and integrated circuits parts 8 consuming a large amount

of power. The adjustment electronic parts 7 are configured to protrude from the rear side of the dielectric substrate 2a through an opening 41 that has been fabricated on the metal plate 4a by etching, drilling or other processing methods. Integrated circuit parts 8 are fitted directly to the metal plate 4a through a metal block 8a for improved heatsink efficiency. The metal block 8 can be formed for example from copper, a copper-tungsten alloy, iron, silver and gold.

Wires 9 are employed for the connection of the dielectric substrates 2a and 2b. In addition, terminals 10a provided for input in, and output to, the external circuit (not shown in the figures) protrude from the rear side of the dielectric substrate 2a through an opening 42 formed in the metal plate 4a by etching, drilling or other processing methods. In the same manner, terminals 10b are configured to protrude from the rear side of the metal plate 4b through an opening 43 thereof.

Furthermore, in a section denoted by A in Fig. 2, a metal plate 11a or 11b is adhered to the grounding layer 13, which has been exposed upward (i.e., in the direction indicated by Y in Fig.2), in the dielectric substrate 2b consisting of a multilayer wiring substrate.

Figures 3 are exploded side views of the section A. Figure 3 (a) shows an example where an angular U-shaped metal plate 11a is arranged along the edges on the exposed grounding layer 13 of the dielectric substrate 2b. Figure 3 (b) illustrates an example in which a metal plate 11b is arranged to adhere to the whole exposed surface of the grounding layer 13 of the

dielectric substrate 2b. In either case, the metal plate 11a or the metal plate 11b is in contact with the surrounding metal plates 4c, 4d and 4e, enabling heat conduction from the metal plates 11a or 11b to the chassis 4.

As shown in Fig. 2, a heatsink 12 may be installed on the metal plate 11b. Such installation can be fixed with locking nuts and bolts or adhesives, for example. This structure allows heat generated from the dielectric substrate 2b to accumulate temporarily in the heatsink 12, effectively curbing temperature fluctuations that may occur in the dielectric substrate 2b.

While representative embodiments of the present invention have been described thus far, the conceivable embodiments are not limited to those herein described, and various modifications are possible. For example, while the chassis 4 consists solely of the metal plates 4a, 4b, 4c, 4d and 4e according to the embodiments herein provided, it is also possible to employ a metal plate only for a part of the chassis.

Figures 4 illustrates the optical communications module 1 employing resin plates 14a, 14c and 14d, instead of the metal plate 4a, 4c and 4d. While Fig. 4 (a) is a sectional side view of the optical communications module, Fig. 4 (b) gives its perspective view. The resin plates 14a, 14c and 14d have the dielectric substrates 2a, 2c and 2d respectively attached thereto. Differing from these, the dielectric substrate 2b consists of a metal base substrate with a metal plate 4b formed on the rear side. While the dielectric substrates 2a, 2c and 2d are equipped with parts generating relatively low heat, the

dielectric substrate 2b has relatively high heat-generating parts mounted thereon.

This structure makes it possible to reduce heat interference that may occur between the dielectric substrates 2a, 2c and 2d, and the dielectric  
5 substrate 2b, enabling further improvement in performance of the optical communications module.

In the aforementioned examples, the metal plates 4a, 4b, 4c, 4d and 4e are assembled and adhered together. However, it is also possible to form some metal plates by an integral molding method such that they are  
10 combined from the beginning.

Figure 5 (a) is a perspective view of the chassis with a rectangular section, which is formed by assembling two members by fitting one edge of one member into the groove of the other, wherein one member consists of metal plates 4a and 4c formed into a single-piece having an L-shaped section  
15 with a groove 15a on the edge thereof, and the other member consists of metal plates 4b and 4d formed into a single-piece having an L-shaped section with a groove 15b on the edge thereof. Interlocking one component with the other in this manner ensures thermal connection among the metal plates 4a, 4b, 4c and 4d.

20 Figure 5 (b) is a front view of another chassis with a rectangular section, which is formed by fitting two edges of the metal plate 4b into grooves 15c and 15d provided on the edges of a single piece member having an angular U-shaped section consisting of the metal plates 4a, 4c and 4d. Also in this

example, interlocking one component with the other in this manner allows thermal connection among the metal plates 4a, 4b, 4c and 4d.

For the embodiments shown in both Figs. 5 (a) and 5 (b), it is preferable that processing such as welding, soldering, or adhesive bonding be  
5 conducted to fix the metal plates firmly in the grooves.

In addition, various modifications can be made within the scope of the present invention.